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(54) **Multi-flighted notched metering auger**

(57) An auger is provided for discharging a uniform flow of material, particularly dry solids, through a feeding system. The auger has a shaft (4, 104) and at least one flight (20, 120) extending outward from the shaft for delivering a flow of material from a first end to a second end of the shaft. The flight has at least one notch (30, 130, 132) in its outer perimeter proximate to the second end of the shaft. The auger may be used in a material

feeding system having a supply hopper (402) and a discharge conduit (408) mounted to a feed trough (404). The auger is disposed in the trough and extends into the discharge conduit. The auger is rotated by a motor (414) to drive the material from the feed trough through the discharge spout. The speed of the motor (and hence the feed rate of the material) may be controlled based on the volume of material being fed, the weight of material being fed or the loss-in-weight of the system.

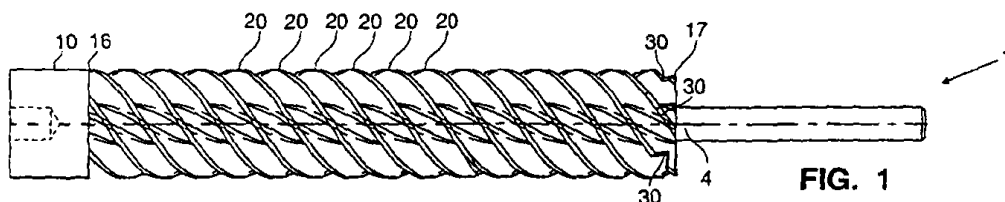


FIG. 1

Description

The invention relates generally to augers which are used to produce a flow of material within an enclosure and particularly to augers used in moving dry solids through a feeding system. The invention also relates to material handling and feeding systems that use such an auger.

Material feeding systems utilize various types of mechanical components, including augers, to move material from the body of the feeding system to a discharge opening at a predetermined rate. Two types of common feeding systems are volumetric feeding systems and gravimetric feeding systems. Volumetric feeding systems control the discharge rate based on the speed of the auger and its volumetric displacement (volume output per revolution). Gravimetric feeding systems control the discharge rate based on weight.

Common materials used in material feeding systems are dry solids, typically including powders, granules, strands, etc. Such solids, especially those which are adhesive, cohesive, fibrous, or hygroscopic, sometimes cause process variations because of the tendency of the common auger to produce uneven or nonuniform flow. A nonuniform (pulsating) flow can inhibit flow-dependent processes beyond the feeding system. Thus, the short-term efficiency and effectiveness of the metering apparatus is impaired. It is, thus, highly desired that, for many processes, the flow of material through the discharge outlet by the auger be as uniform as possible.

The nonuniform flow of material in a dry solids feeding system is primarily due to the speed of the auger combined with the size of the gate openings (flights) of the auger. Material clumps together causing it to be delivered out of the feeding system in "pulses" at different rates and in different size chunks. This problem is exacerbated at slower speeds where the pulses are farther apart and produce even larger chunks of material. The number of pulses that are generated typically depends on the number of flights on the auger. Conventionally, augers typically have one flight, and thus, deliver only one pulse per rotation. This results in an uneven flow of material. Intermeshing twin or double augers produce two pulses per revolution.

One auger which attempts to overcome these problems is disclosed in U.S. Patent 4,206,841 to Lundgren. Lundgren discloses a screw conveyor which extends through a barrel to drive material from an inlet at one end of the barrel to an outlet at the other end of the barrel when the screw is rotated. The screw has a central stem with a single flight extending along its length. A plurality of blade segments are mounted at the discharge end of the screw. Each blade segment has a base portion attached at its inner periphery to the central stem and a wing portion distal to the stem. The wing portion defines an arc larger than the base portion so that each blade segment defines an open space between its inner periphery and the central stem. In addition, each blade

segment has a pitch that may vary from that of the single flight.

There remains, however, the need for a simple auger that can feed material uniformly at a variety of operating speeds.

It is therefore an object of the present invention to provide a simple auger that is capable of feeding materials, in particular dry solid materials, uniformly at a variety of operating speeds.

It is a further object of the present invention to provide a material feeding apparatus having a simple auger that is capable of feeding materials, in particular dry solid materials, uniformly at a variety of operating speeds.

The present invention provides an auger which has a shaft from which extends at least one flight for conveying material from a first end of the shaft to a second end of the shaft upon rotation of the auger. The auger further comprises at least one notch in the outer perimeter of the flight proximate to the second end of the shaft.

In another aspect of the present invention, the above auger is used in a material feeding system. The feeding system has a supply hopper and a discharge conduit mounted to a feed trough. The auger, described above, is disposed in the trough and extends into the discharge conduit. The auger is rotated by a motor to drive the material from the feed trough through the discharge spout. The speed of the motor (and hence the feed rate of the material) may be controlled based on the volume of material being fed, the weight of material being fed or the loss-in-weight of the system.

The invention will now be described in detail with reference to the accompanying drawings in which:

FIG. 1 is a side elevational view of a six flighted auger according to the present invention;

FIG. 2 is an end elevational view of the discharge end of the auger of FIG. 1;

FIG. 3 is a side elevated view of a three flighted auger in an alternative embodiment of the present invention;

FIG. 4 is an end view of the discharge end of the auger of FIG. 3;

FIG. 5 is a side elevational view of a volumetric feeding system employing the auger of FIG. 3 according to the present invention;

FIG. 6 is a side elevational view of a loss-in-weight weigh feeding system employing the auger of FIG. 3 according to the present invention; and

FIG. 7 is a side elevational view of a weigh auger weigh feeding system employing the auger of FIG. 3 according to the present invention

Referring to FIG. 1, a preferred embodiment of the auger of the present invention is shown. The auger 7 is provided with a base 10. From base 10 extends shaft 4. Six flights 20 project outward from shaft 4. Each flight 20 has a first end 16 and a second, discharge end 17. The first end 16 of each flight 20 terminates at base 10.

As best seen in FIG. 2, which is an end elevational view of the discharge end of auger 7, a wedge-shaped notch 30 is cut into the outer perimeter of each flight proximate the discharge end 17 of the flight 20. The notches 30 of a preferred embodiment are wedge-shaped having an angle of 90° at the apex. When viewed from the end, as shown in Figure 2, it can be seen that the notches do not extend to the shaft. The notches define an arc of about 30° in the outer perimeter of the auger. It should be apparent, however, that notches of other shapes (e.g., semicircles, rectangles, etc.) and other sizes may be used and still practice the present invention.

Preferably, each notch 30 is positioned radially about the shaft 4 so as to be centered between adjacent flight ends 17. This produces a discharge pulse of material at a point half-way between those produced by the adjacent flight ends 17 as the auger 7 is rotated. For example, in the auger 7 of FIG. 2, the flights 20 terminate at 60° intervals around the shaft 4, beginning at 0° (i.e., top of the figure). The notches 30 are also spaced at 60° intervals, but with the first notch centered at approximately 30°. Accordingly, the notches 30 are centered between adjacent flight ends 17 and symmetrically positioned about the shaft 4. This arrangement has been found to provide a very uniform flow of material since the notches 30 and flight ends 17 produce multiple discharge pulses at equal intervals as the auger 7 is rotated.

The auger 7 is machined out of a solid bar of steel. The outer diameter of the auger 7 can typically range from 1 to 8 inches and the outer diameter of the shaft will vary proportionately. The length of the auger is dependent upon the application. The flights are typically each 1/8 to 1/4 inch thick and have a pitch proportional to its size. The auger 7 of FIGS. 1 and 2 has an outer diameter of 2 inches, a shaft outer diameter of 3/4 inch and a flight thickness of 1/8 inch.

FIGS. 3 and 4 show an alternative embodiment of the present invention. Similar to auger 7 of FIGS. 1-2, auger 107 consists of a base 110 and a shaft 104 fixed to the base 110. However, the auger 107 of FIGS. 3 and 4 includes only three flights 120, rather than six. Each flight 120, therefore, terminates at 120° intervals beginning at 0°. In addition, as seen in FIG. 4, each flight 120 has two notches 130, 132 cut into its outer perimeter proximate the discharge end of the flight. The notches 130, 132 are similar to those in the six flighted auger but are spaced about shaft 104 at different intervals to account for the different number of flights and notches. Accordingly, if the end of the top flight in FIG. 4 is taken as 0°, the two notches 130, 132 in the first flight are centered at 36° and 84°, respectively, the notches 130, 132 in the second flight are centered at 156° and 204°, respectively, and the notches 130, 132 in the last flight are centered at 276° and 324°, respectively.

It would be appreciated from the above description that the circumferential distribution of notches shown in

Figure 4 is not regular. It is of course possible to form the notches at intervals of 40° from the end edges of the auger flights, so as to achieve an even circumferential distribution.

Referring to FIG. 5, the three-flight auger 107 is illustrated in phantom as a part of a conventional volumetric dry solids feeding system 200. Acceptable volumetric feeding systems are commercially available from Acrison, Inc., 20 Empire Boulevard, Moonachie, NJ 07074, for example Acrison Model 130. The feeding system includes a material supply hopper 202 mounted to a feed trough 204, which in turn is mounted to a base 206. The supply hopper 202 is mounted above the feed trough 204 such that material flows from the supply hopper 202 into the feed trough 204. The auger 107 is disposed longitudinally in the feed trough 204 with its base 110 connected via gear assembly 212 to motor 214, which causes rotation of the auger 107 within the trough 204. The auger 107 extends out one end of the feed trough 204 into a discharge conduit 208 which is also mounted to the feed trough 204. The flights 120 of the auger terminate at the end of the discharge conduit 208.

A discharge spout 210 having opening 216 is mounted to the end of the discharge conduit 208. The shaft 104 is connected to the discharge spout 210 by bearing assembly 218. This mounting arrangement helps maintain the axial alignment of the auger 107 and the discharge conduit 208. It should be noted, however, that the discharge spout 210 is not required for the proper operation of the system. In the absence of the discharge spout 210, the shaft 104 could terminate at the end of the discharge conduit 208.

In operation, the motor 214 causes the controlled rotation of the auger 107. This, in turn, causes the material fed from supply hopper 202 to be driven from the feed trough 204, through the discharge conduit 208 and out opening 216 of the discharge spout 210. The volume of material fed per revolution of the particular auger 107 is predetermined so that the desired amount of material to be fed may be controlled by varying the speed of the motor 214. The speed of the motor 214 is controlled in a conventional manner by a variable speed motor controller, for example Model 060 SCR/DC DC motor controller available commercially from Acrison, Inc., as is well known in the art.

Where even greater accuracy is desired, an auger according to the present invention may be used in a gravimetric feeding system. Gravimetric systems control the feeding of material by weight, and thereby compensate for changes in density, for irregular product density and/or for irregular flow or handling characteristics.

One type of gravimetric feeding system is a weigh auger weigh feeding system, such as the Model 203B Series weigh auger weigh feeding system available from Acrison, Inc. Referring to FIG. 7, the weigh auger feeding system 400 has a supply hopper 402 mounted to a feed trough 404, which in turn is mounted to a base

406, similar to the volumetric feeding system 200 described above. Also as in the volumetric feeding system 200, the auger 107 is disposed longitudinally in the feed trough 404, is connected via gear assembly 412 to motor 414 and extends into discharge conduit 408. The weigh auger feeding system differs from the volumetric feeding system 200, however, in that the weigh auger system 400 includes a scale 420 which measures the weight of the material discharged from the discharge conduit 408 as it passes across an auger in a second discharge conduit 428 during operation. This measured weight is compared to an expected or "set" weight, by for example an MD-II 2000™ Weigh Feeder Controller available from Acrison, Inc., causing the generation of a control signal. The control signal is input into the motor controller (described above) to either increase, decrease or maintain the speed of the feed motor 414 and achieve the desired feed rate.

Another type of gravimetric feeding system is referred to as a loss-in-weight weigh feeding system. One such commercially available example is the Model 404 loss-in-weight weigh feeding system, also available from Acrison, Inc. In loss-in-weight feeding systems, the entire apparatus 300 is mounted on a weighing mechanism or scale 320, for example at its base 306 as shown in FIG. 6. The scale 320 continuously monitors the weight of the entire system, including feed trough 304, discharge conduit 308, spout 310, supply hopper 302 and the material being fed, so that the loss in weight caused by the discharge of material can be continually tracked. The amount of material to be fed may then be accurately controlled by varying the speed of the motor in response to the rate of weight loss of the system. Again, the manner in which the feed rate of material is controlled in a loss-in-weight feed system is well known in the art and may include, for example, the MD-II 2000 Weigh Feeder controller and Model 060 SCR/DC DC motor controller as described above.

The augers of the present invention produce a multiple number of pulses per revolution as compared to the conventional single or double augers which only produce one or two pulses per revolution, respectively. The six flighted auger of FIGS. 1-2 generates twelve pulses per rotation while the auger of FIGS. 3-4 generates nine pulses per rotation. Consequently, the pulses produced by the auger of the present invention are smaller, resulting in a more uniform flow of material.

In addition to the increase in the number of discharge pulses, produced by the combination of the number of flights and the number of notches located at the discharge end of the auger, the augers of the present invention generate an overflow of material through the notches. This overflow is produced by the centrifugal or rotational motion of the auger as it discharges material from the discharge end. The overflow created at the notches further enhances the uniformity of the flow of material, which has already been metered. Overall, it has been found that the augers of the present invention

deliver material 10-20 times more consistently and accurately than conventional augers at sample intervals as small as .1 seconds, while rotating at speeds typically between 20-300 RPM.

It has been found that the ideal operating speed, for the augers of the present invention, is usually between 20 and 300 RPM. At these speeds, the wear and tear on both the auger and related machinery is minimized. It should be noted, however, that the augers of the present invention are in no way limited to these range of speeds.

In an alternative embodiment, not illustrated, the "notches" in the flights of the auger may be configured as openings penetrating through the flights at locations adjacent the outer periphery of the flight. The openings may be formed by drilling through the flights, for example, and are sufficiently close to the periphery of the flight for material to pass through the openings as the auger rotates.

The present invention has been described in terms of preferred embodiments thereof. Other embodiments, features and variations within the scope of the invention will, given the benefit of this disclosure, occur to those having ordinary skill in the art.

Claims

1. An auger for feeding material comprising:
 - a shaft having a first end and a second end; and
 - at least one flight mounted to said shaft for conveying material from said first end toward said second end, said at least one flight having at least one notch proximate the second end.
2. An auger according to claim 1 wherein each of said flights has the same number of notches.
3. An auger according to claim 1 or claim 2 wherein said notches are disposed symmetrically about said shaft.
4. An auger according to claim 1 or claim 2 wherein said notches are disposed at equal intervals about said shaft.
5. An auger according to claim 1 or claim 2 wherein said notches are radially disposed about said shaft so as to be centered between the termination of adjacent flights.
6. An auger according to any preceding claim wherein the number of flights is three.
7. An auger according to claim 6 wherein each of said flights has two notches.

8. An auger according to claim 6 or claim 7 wherein said flights terminate at 0°, 120° and 240° relative to each other about said shaft.
9. An auger according to claim 8 as dependent on claim 7 wherein said notches are disposed at approximately 36°, 84°, 156°, 204°, 276° and 324° relative to each other and relative to said flights about said shaft.
10. An auger according to any of claims 1 to 5 wherein the number of flights is six.
11. An auger according to claim 10 wherein each of said flights has one notch.
12. An auger according to claim 10 or claim 11 wherein said flights terminate at 0°, 60°, 120°, 180°, 240° and 300° relative to each other about said shaft.
13. An auger according to claim 12 wherein said notches are disposed at approximately 30°, 90°, 150°, 210°, 270° and 330° relative to each other and relative to said flights about said shaft.
14. An auger according to any preceding claim wherein said at least one notch is wedge shaped.
15. An auger according to claim 14 wherein said at least one notch has an apex having approximately a 90° angle.
16. An auger according to claim 14 or claim 15 wherein said at least one notch does not extend to said shaft.
17. An auger for feeding material comprising:
a base;
a shaft mounted to said base; and
a plurality of flights mounted to said shaft, each of said flights having at least one notch distal said base.
18. An auger according to claim 17 wherein the number of flights is six and each of said flights has one notch, wherein said flights terminate at 60° intervals about said shaft and wherein said notches are disposed at 60° intervals about said shaft, offset from the termination of said flights by 30°.
19. An auger according to claim 17 wherein the number of flights is three and each of said flights has two notches, wherein said flights terminate at 120° intervals about said shaft.
20. An auger according to any of claims 17 to 19 wherein said at least one notch is wedge shaped.
21. A material feeding system comprising:
a feed trough;
a supply means for supplying a material to be fed to said feed trough;
an auger disposed in said trough, said auger comprising:
a base;
a shaft mounted to the base; and
at least one flight mounted to said shaft, said at least one flight having at least one notch distal said base; and
a means to rotate said auger.
22. A feeding system according to claim 21 wherein said supply means comprises a supply hopper mounted to said feed trough.
23. A feeding system according to claim 21 or claim 22 wherein said rotation means comprises a motor operably connected to the base of said auger.
24. A feeding system comprising:
a supply hopper;
a feed trough mounted to said supply hopper;
a discharge conduit having a discharge end mounted to said feed trough;
an auger disposed in said trough and extending into said discharge conduit, said auger having:
a shaft; and
at least one flight mounted to said shaft, said at least one flight having at least one notch proximate said discharge end of said discharge conduit; and
a motor operably engaged to said auger at said base.
25. A feeding system according to claim 23 or claim 24 further comprising means to control the speed of said motor to feed a desired volume of said material.
26. A feeding system according to claim 23 or claim 24 further comprising:
means to measure a weight of the material; and
means to control the speed of said motor to feed a desired quantity of said material based on weight.
27. A feeding system according to claim 26 wherein said weight measuring means comprises:
means to measure a weight of the feeding system including the material; and
means to determine a loss-in-weight of said feeding system and said material due to said material being fed.

28. A method of feeding a material with an apparatus having a feed trough, a discharge conduit having a discharge end mounted to said feed trough, and an auger disposed in said trough and extending into said discharge conduit, said auger having a shaft, and at least one flight mounted to said shaft, said at least one flight having at least one notch proximate said discharge end of said discharge conduit, the method comprising the steps of:

providing a supply of material to be fed to said feed trough; and

rotating said auger in said feed trough, thereby driving said material through said discharge conduit toward said discharge end and discharging said material from said discharge end in a plurality of pulses.

29. A method according to claim 28 further comprising the step of varying the speed of rotation of the auger to feed a desired volume of said material.

30. A method according to claim 28 further comprising the steps of:

monitoring the weight of said material as it is driven by said auger; and
varying the speed of rotation of the auger to feed a desired quantity of said material based on weight.

31. A method according to claim 28 further comprising the steps of:

monitoring a loss-in-weight of said material feeding apparatus and said material; and
varying the speed of rotation of the auger to feed a desired quantity of said material based on the loss-in-weight.

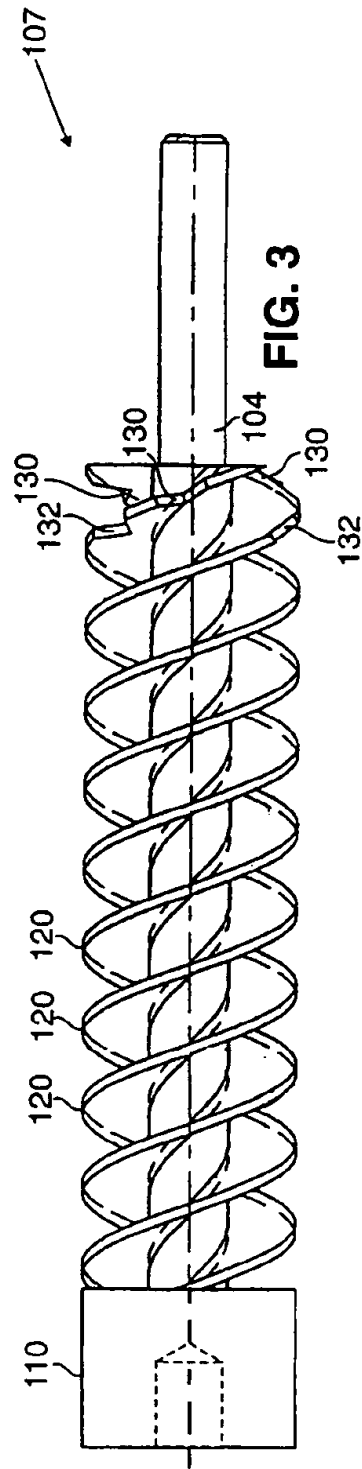
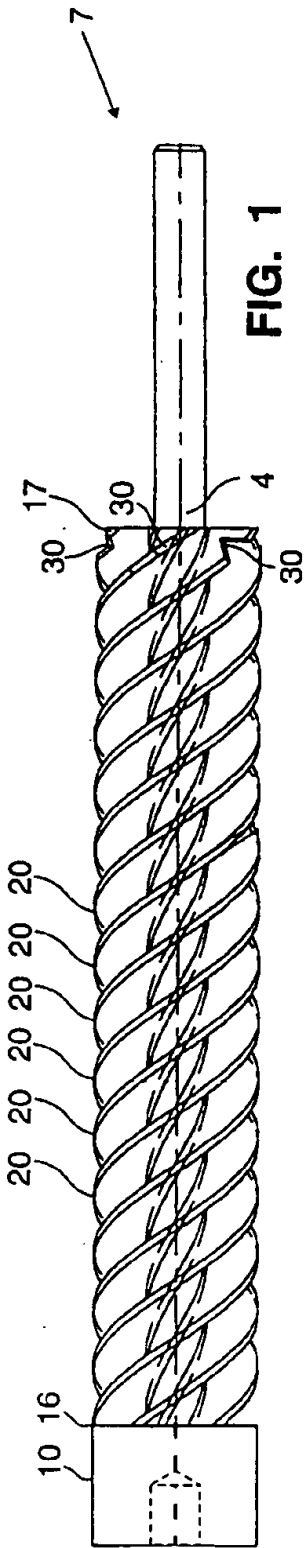
32. A method according to any of claims 28 to 31 wherein the number of discharge pulses per revolution of the auger is greater than the number of flights.

33. An auger for feeding material comprising:

means to drive material from a first end of said auger to a discharge end of said auger upon rotation of said auger; and

means to produce a plurality of discharge pulses of material at said discharge end upon rotation of said auger.

34. An auger according to claim 33 wherein said discharge pulse producing means comprises means to produce said discharge pulses at equal intervals as said auger is rotated.



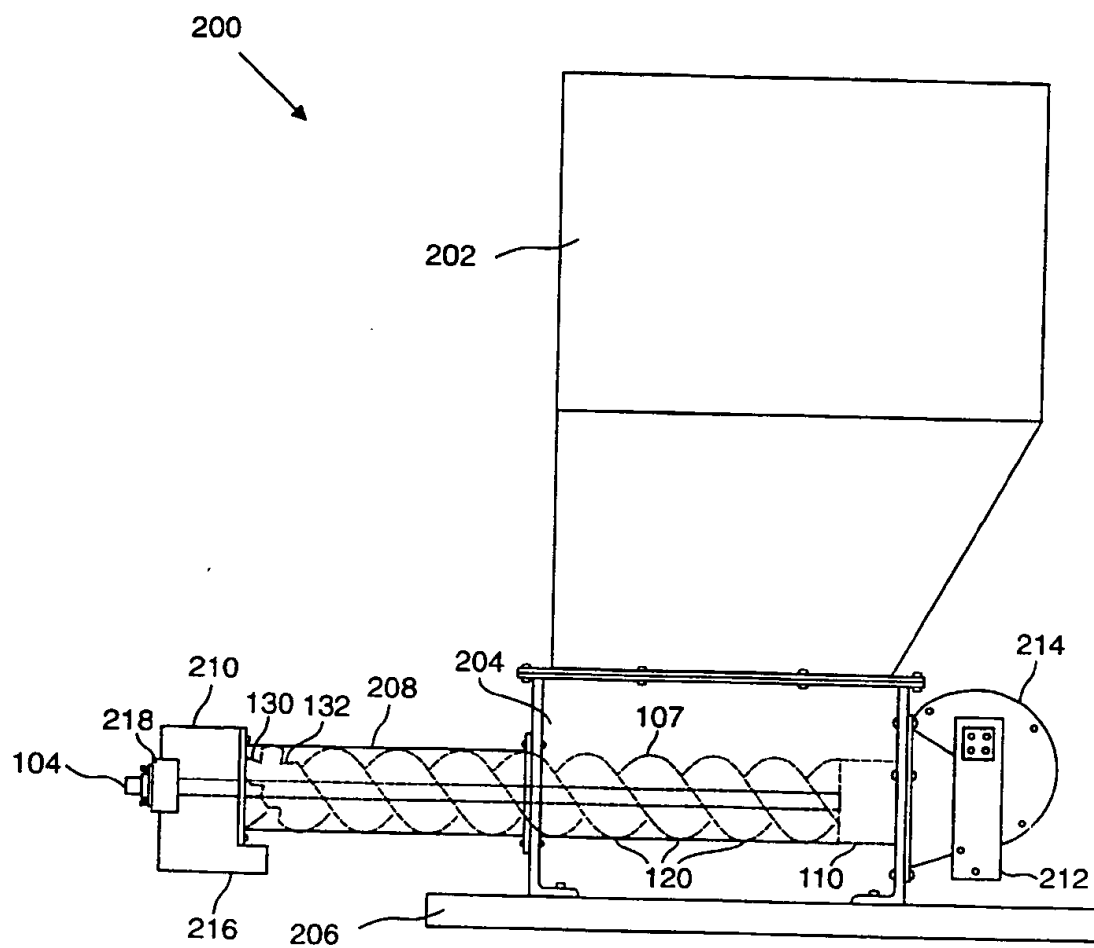


FIG. 5

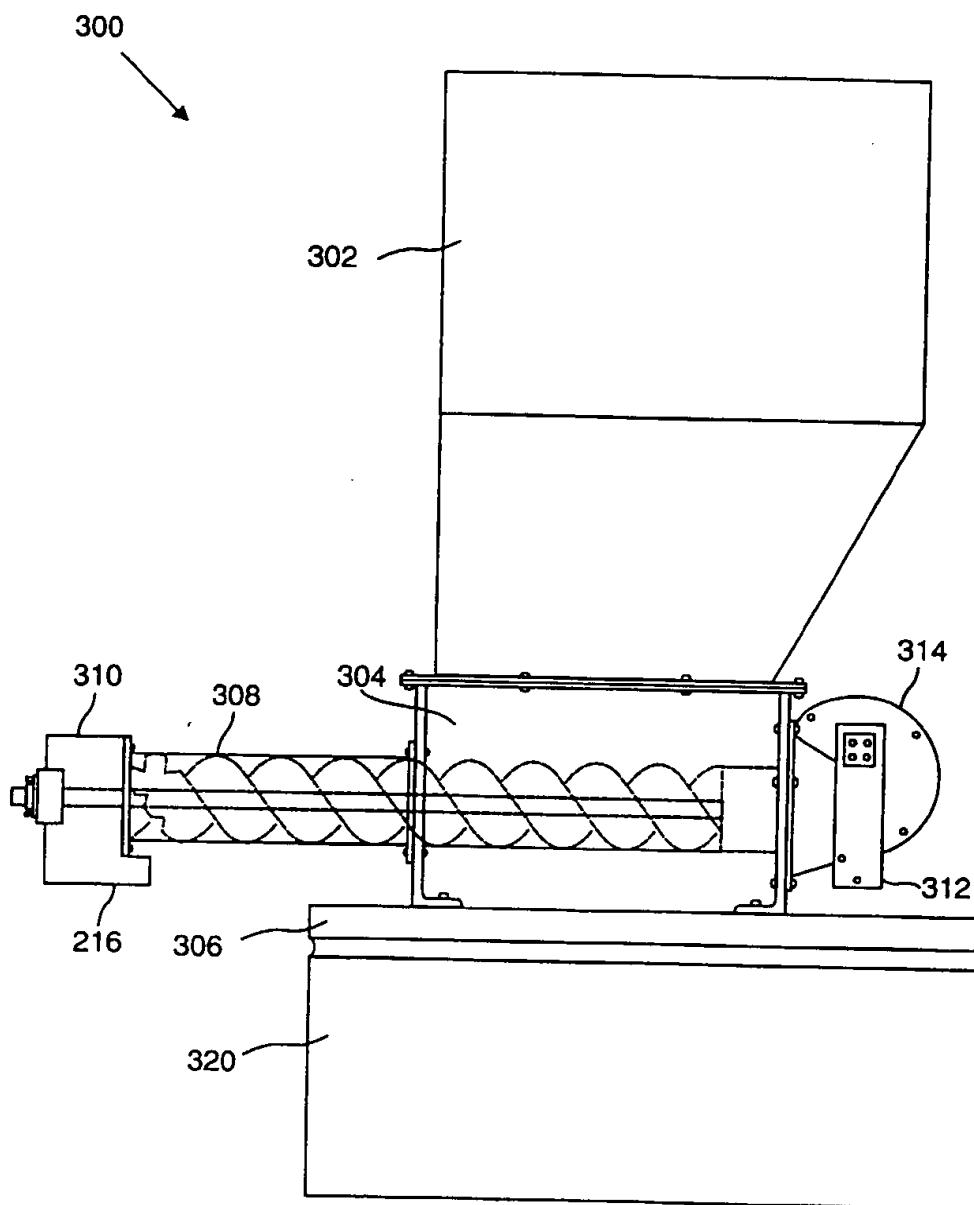


FIG. 6

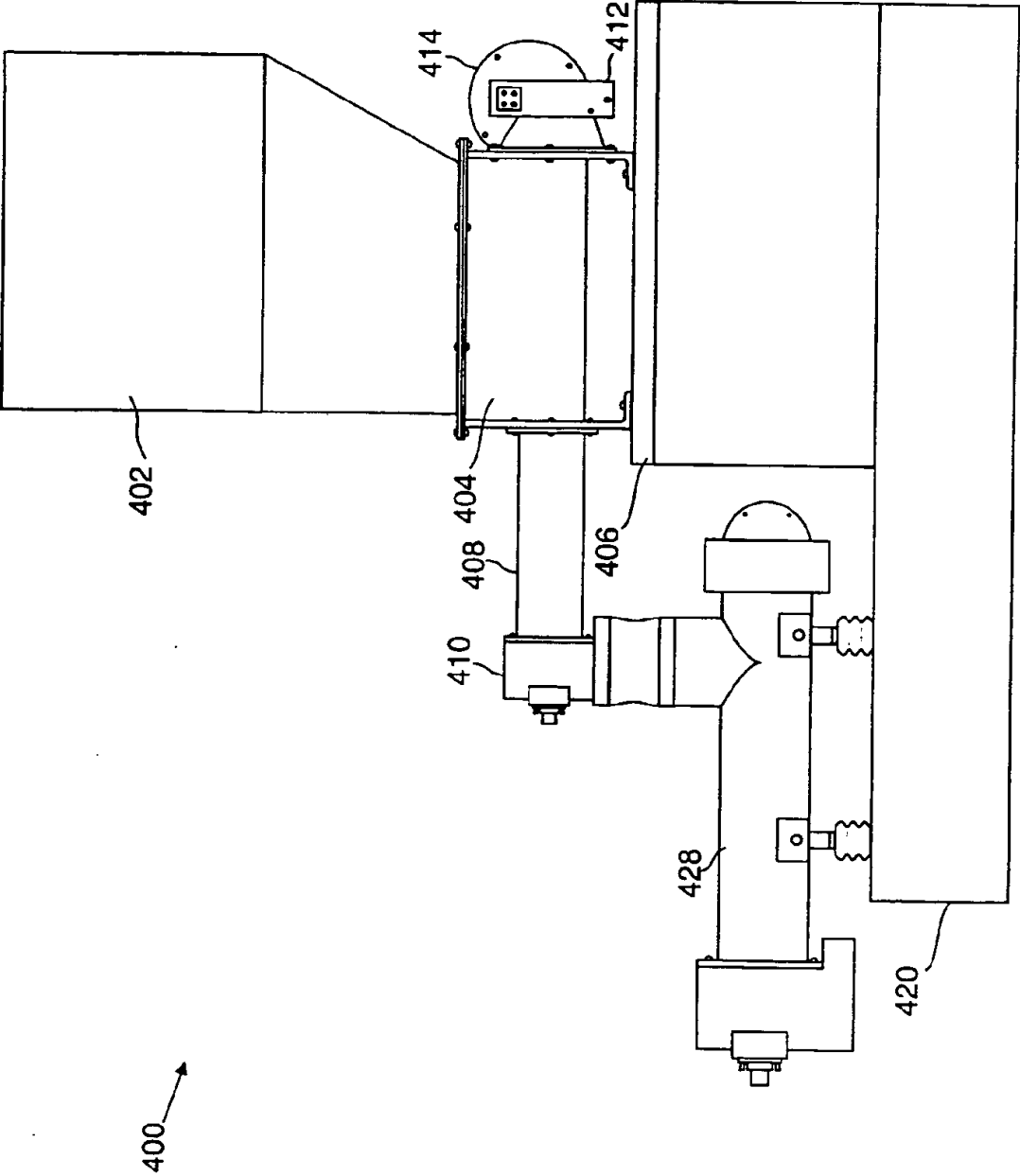


FIG. 7



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 8665

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D, A	US 4 106 841 A (LUNDGREN)	1, 17, 21, 24, 28	B65G33/26
X	* the whole document *	33, 34	
A	PATENT ABSTRACTS OF JAPAN vol. 092, no. 005, 31 May 1996 & JP 08 026453 A (ASAHI SANGYO), 30 January 1996, * abstract *	1, 17	
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 010 (M-1199), 13 January 1992 & JP 03 232610 A (KUBOTA CORP), 16 January 1991, * abstract *	1, 17	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B65G
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 16 February 1998	Examiner Martens, L
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X particularly relevant if taken alone Y particularly relevant if combined with another document of the same category A technological background O non-written disclosure P intermediate document			

